

Claims

- [c1] 1. A fault current limiter (FCL) comprising:
an air core flat clock spiral inductor comprising wound electrically conductive material and insulated turns;
two terminations configured for attaching the spiral inductor in series with a power carrying conductor.
- [c2] 2. The FCL of claim 1 wherein the electrically conductive material is copper, aluminum, or combinations thereof.
- [c3] 3. The FCL of claim 1 wherein the electrically conductive material is a metal, a metal alloy, or a conductive polymer.
- [c4] 4. The FCL of claim 3 wherein the wound electrically conductive material comprises a polygonal shape.
5. The FCL of claim 4 wherein the polygonal shape comprises corners .
- [c5] 6. The FCL of claim 4 wherein the polygonal shape comprises a continuous polygonal shape.
- [c6] 7. The FCL of claim 6 wherein the spiral inductor comprises a cylinder.
8. The FCL of claim 4 wherein the wound electrically conductive material comprises a multiple-turn wound sheet.
- [c7] 9. The FCL of claim 4 wherein the wound electrically conductive material comprises coupled segments of electrically conductive material.
- [c8] 10. The FCL of claim 4 wherein the wound electrically conductive material includes radially extending fins.
- [c9] 11. The FCL of claim 4 wherein the wound electrically conductive material comprises stranded electrically conductive material.
- [c10] 12. The FCL of claim 11 wherein at least one strand of the stranded electrically conductive material comprises a hollow strand.
- [c11] 13. The FCL of claim 12 further comprising a fluid within the hollow strand.

- [c12] 14. The FCL of claim 1 wherein the electrically conductive material comprises at least one opening extending therethrough.
- [c13] 15. The FCL of claim 14 further comprising a fluid within the opening.
- [c14] 16. The FCL of claim 1 further comprising fluid between turns of the electrically conductive material.
- [c15] 17. The FCL of claim 16 wherein the fluid is a liquid, a gas, or a combination thereof.
- [c16] 18. The FCL of claim 16 wherein the fluid is air, helium, oil, or water.
- [c17] 19. The FCL of claim 16 further comprising a casing containing the fluid.
- [c18] 20. The FCL of claim 19 wherein the casing comprises a tube wrapped around the electrically conductive material.
21. The FCL of claim 1 wherein the wound sheet of electrically conductive material further comprises a insulation layer 17 on at least one surface of the electrically conductive material.
- [c19] 22. The FCL of claim 21 wherein the insulation layer comprises a powder coating.
- [c20] 23. The FCL of claim 22 wherein the powder coating comprises a resin.
- [c21] 24. The FCL of claim 23 wherein the resin is an epoxy, a polypropylene, a polyethylene, a polyvinyl chloride, a polyetheretherketone, a polyetherketoneketone, an acrylic urethane, a polyester, a silicone epoxy, a polyester resin with a triglycidyl isocyanurate curing (TGIC) agent, or combinations thereof.
- [c22] 25. The FCL of claim 21 wherein the insulation layer comprises an insulating tape.
- [c23] 26. The FCL of claim 25 wherein the insulating tape is silicone, glass, an aramid, a polyolefin, a polyester, a polyimide, a polypropylene, a polyethylene, a polyvinyl chloride, a polyetheretherketone, a polyetherketoneketone, an acrylic urethane, a polyester resin with triglycidyl isocyanurate curing (TGIC) agent, or combinations thereof.

- [c24] 27. The FCL of claim 21 wherein the insulation layer comprises a shrink wrap.
- [c25] 28. The FCL of claim 27 wherein the shrink wrap comprises a polyolefin or a polytetrafluoroethylene, for example.
- [c26] 29. The FCL of claim 1 further comprising a housing surrounding the spiral inductor, the housing comprising walls.
- [c27] 30. The FCL of claim 29 wherein at least one of the walls comprises at least one vent.
- [c28] 31. The FCL of claim 29 wherein the housing comprises a polygonal shape.
- [c29] 32. The FCL of claim 29 wherein at least one of the walls comprises a metal material.
- [c30] 33. The FCL of claim 29 wherein at least one of the walls comprises a non-magnetic material.
- [c31] 34. The FCL of claim 33 wherein the non-magnetic material comprises an insulating material.
35. The FCL of claim 34 wherein the insulating material comprises a polymer, a composite, or a polyofin.
- [c32] 36. The FCL of claim 33 wherein the non-magnetic material comprises a metallic, non-magnetic material.
37. The FCL of claim 29 wherein each one of the walls is in electrical contact with at least one other one of the walls.
- [c33] 38. The FCL of claim 37 wherein the housing further comprises at least one stack of magnetic laminations between at least one of the walls and the spiral inductor.
39. The FCL of claim 29 wherein each one of the walls is electrically isolated from the other walls.
40. The FCL of claim 39 wherein the housing further comprises at least one stack of magnetic laminations between at least one of the walls and the spiral inductor.
- [c34] 41. The FCL of claim 29 wherein the air core spiral inductor comprises a plurality of air core spiral inductors, with each one of the plurality of air core spiral inductors

comprising a wound sheet of electrically conductive material and insulated turns and situated within the housing.

- [c35] 42. The FCL of claim 41 wherein the plurality of air core spiral inductors comprises three air core inductors and wherein each one of the three air core spiral inductors is configured to be coupled to a separate phase of the power carrying conductor.
- [c36] 43. The FCL of claim 41 wherein at least some of the plurality of air core spiral inductors are configured to be coupled to a single phase of the power carrying conductor.
- [c37] 44. The FCL of claim 41 further comprising at least one magnetic shield 74 between at least two of the plurality of spiral inductors.
- [c38] 45. The FCL of claim 1 wherein the air core spiral inductor comprises a plurality of air core spiral inductors, with each one of the plurality of air core spiral inductors comprising a wound sheet of electrically conductive material.
- [c39] 46. The FCL of claim 1 further comprising at least one cooling unit (26) configured for cooling the spiral inductor.
- [c40] 47. The FCL of claim 46 wherein the at least one cooling unit is a fan, an air conditioner, an auxiliary cooling unit, or a combination thereof.
- [c41] 48. The FCL of claim 47 further comprising a housing surrounding the spiral inductor, wherein the housing comprises at least two separate fan openings, and wherein the at least one cooling unit comprises at least two fans, each configured to provide cooling air through a respective one of the at least two separate fan openings.
- [c42] 49. The FCL of claim 47 further comprising at least one heat pipe, wherein the auxiliary cooling unit comprises a heat pipe controller.
- [c43] 50. The FCL of claim 47 further comprising fluid between turns of the electrically conductive material.
- [c44] 51. The FCL of claim 47 wherein the electrically conductive material comprises at least one opening extending therethrough, and the FCL further comprising a fluid

within the opening.

- [c45] 52. A fault current limiter (FCL) comprising:
three air core flat clock spiral inductors, each inductor comprising a cylindrically wound sheet comprising copper and a insulation layer on at least one surface of the copper, each inductor configured for being attached in series with a busway; a housing surrounding the three air core spiral inductors, the housing comprising wall; and
at least one cooling unit configured for providing cooling air the three spiral inductors.
- [c46] 53. The FCL of claim 52 wherein the insulation layer is a powder coating, an insulating tape, or a shrink wrap.
- [c47] 54. The FCL of claim 53 wherein the insulating layer comprises a resin, silicone, glass, an aramid, a polyofin, a polytetrafluoroethylene, or combinations thereof.
55. The FCL of claim 52 wherein at least one of the walls comprises at least one vent.
- [c48] 56. The FCL of claim 52 wherein at least one of the walls comprises an insulating material.
57. The FCL of claim 52 wherein the housing further comprises at least one stack of magnetic laminations between at least one of the walls and the air core spiral inductors.
58. The FCL of claim 52 wherein each one of the three air core spiral inductors is configured to be coupled to a separate phase of the power carrying conductor.
- [c49] 59. The FCL of claim 52 wherein at least some of the plurality of air core spiral inductors are configured to be coupled to a single phase of the power carrying conductor.
- [c50] 60. The FCL of claim 52 further comprising at least one magnetic shield between at least two of the three of spiral inductors.
- [c51] 61. The FCL of claim 52 wherein the at least one cooling unit is a fan, an air conditioner, an auxiliary cooling unit or a combination thereof.



[c52]

62. The FCL of claim 61 wherein the housing comprises at least two separate fan openings, and where the at least one cooling unit comprises at least two fans, each configured to provide cooling air through a respective one of the at least two separate fan openings.

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